Estimation of Errors Caused by Spherical Approximation of Earth Shape in Coordinates Determination Process of Radio Emission Source Using Bearings

Anatoliy Kochergin, Olexandr Chebotov, Volodymyr Chebotov

Abstract – **Estimation of errors in the process of coordinates' determination of radio source with spherical approximation is conducted. It is demonstrated that for increasing of coordinates' determination accuracy on spreading paths ellepsoidity of earth shape should be taken into consideration.**

Keywords – **Direction finding, spheroid, radio emission source, coordinates determination.**

Direct azimuth mark is used for determination of radio emission source (RES) coordinates by bearings.

In this case unknown coordinates are obtained by solving system of equations

$$A_i = f(B_i, L_i, B_0, L_0), \quad (1)$$

where: $i = 1,2,...,N$, N - number of bearing posts (BP), B_0, L_0 - unknown geodesic coordinates of RES, A_i - measured bearings, B_i, L_i - known geodesic coordinates of direction finders.

Due to the fact that Earth shape is circumscribed by ellipsoid, the system of equations Eq. (1) is presented by differential or integral equation.

One of the methods for solving such system of equations is projecting of earth ellipsoid to the sphere when geodesic coordinates B_i, L_i on ellipsoid are equated to geographic coordinates $j_{i,} l_i$ on sphere. To solve the task correctly this methods need reduction of measured geodesic azimuths A_i to corresponding azimuths a_i on sphere, however, this *measure* increases the complicity of calculations, therefore in the majority of practically realized cases this is neglected and azimuths on ellipsoid and sphere are considered to be equal [1]. This assumption is called spherical approximation of Earth shape.

Estimation of errors in the process of coordinates' determination of RES using spherical approximation is the point of interest. Estimation is done by numerical simulation.

In the simulation for this purpose RES with preset coordinates were placed on the surface of earth ellipsoid and equidistant from RES bearing posts evenly arranged by the azimuth were disposed.

Further bearings of RES on the surface of earth ellipsoid and on sphere without reduction of azimuths were calculated. After that in both cases were determined coordinates of RES and distance between preset and calculated coordinates cha acterizing coordinates' determination error, after that orientation of BP arrangement was changed and the process reiterated.

Anatoliy Kochergin, Olexandr Chebotov, Volodymyr Chebotov – NTC RTS AN PRE, Vosstania sq., 7/8, Kharkiv, 61001, UKRAINE, E-mail: ntcrts@kharkiv.com

Selective result of simulation is illustrated in the form of polar diagram on Fig. 1.

On this figure radial coordinate corresponds to error value of coordinates' determination in km, and azimuth coordinate corresponds to orientation of direction finding network regarding meridian. Disposition of RES and BP is given in figure explanation.

Fig.1. Latitude of RES 50°, distance 2500km, two BP

For errors estimation of coordinates' determination in real direction finding network the second simulation is made; where BP are disposed at four points of their real disposal in Asian region. One of the simulation results is given on Fig. 2.

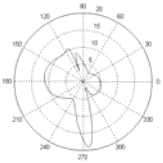

Fig. 2. Azimuth dependence of errors in real network

One more simulation for real direction finding network differs form the previous one by entering to the bearings measured of random errors. One of the results is given on Fig. 3. On this figure left histogram shows distribution of errors using spherical approximation, the right one – exact solution on earth ellipsoid. For these cases mean error comprised 17.7km and 13.3km respectively.

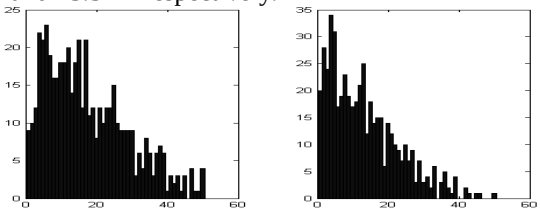

Fig. 3. Errors histograms in real network

Given examples demonstrate that errors caused by spherical approximation can reach the value of 20km and therefore for increasing coordinates accuracy on spreading paths it is necessary to consider real form of earth surface.

REFERENCES

[1] В. П. Кожухов, В. В. Григорьев, С. М. Лукин. Математические основы судовождения: Учеб. пособие. – М.: Транспорт, 1980.